

Human Visual System

Introduction to Computer Vision
CSE 152
Lecture 2

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Intro. Computer Vision

Announcements

- Assignment 0: due Thursday 4/12, will be posted later today
- Kriegman Office Hour: Tuesdays 3:00-4:00
- Read Trucco & Verri: pp. 15-40
- Using Piazza for announcements/discussion
- www.piazza.com

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About working together

- You may work together on homework assignments to discuss ideas and methods, however what you turn in should be your own work and any code should be your own coding. Copying is not permitted.

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Kepler

Kepler, 1604

Eye as an optical instrument

Image is inverted on retina

First such experiment by Scheiner, 1625

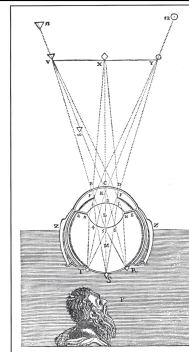


Figure 2.1 Image formation on the retina, according to Descartes. Descartes removed the eye of an ox, scraped its back to make it transparent, and then observed on it from a darkened room "not perhaps without wonder and pleasure" the inverted image of a scene (see [Pirenne 1967]). Such an experiment was performed originally by Scheiner, first with the eyes of sheep and mice, and then, in 1625, with a human eye: the formation of an inverted retinal image was proposed by Kepler in 1604 (see [Polysak 1973]). (From Descartes's *La Dioptrique*, 1637.)

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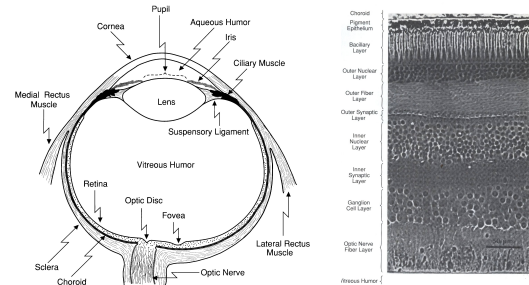
Ways to study human vision

1. Physiologically
2. Phenomenological/Psychophysical
3. Cellular recordings
4. Functional MRI
5. Computational modelling

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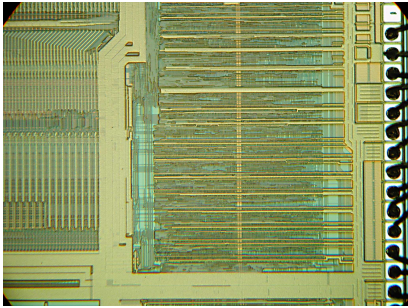
Physiological level



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What does this do?



Can we readily understand whole from understanding pieces?

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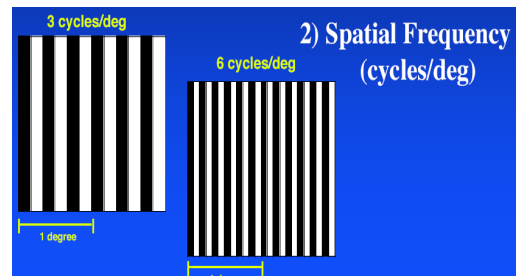
Psychophysical Testing of Subjects



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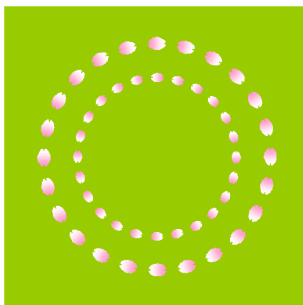
Example:
Show gratings w/ different spatial frequencies



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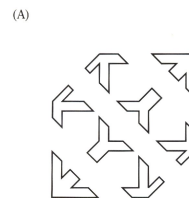
Gradients/Motion



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Perceptual Organization



Occlusion provides a different organization

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Perceptual Organization

(B)



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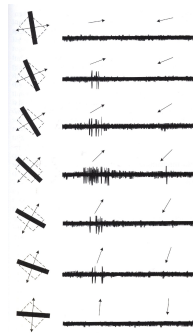
Ways to study human vision

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Single Cell Recordings

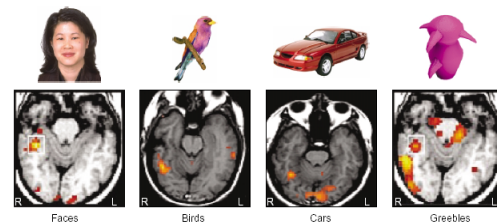


6.12 DIRECTION SELECTIVITY of a cortical neuron's response. The left-hand portion of each panel shows the receptive field location, the orientation of the line stimulus, and the two motion directions. The action potentials shown on the right are the neuron's response to motion in each of the two response directions. The neuron's response depends upon the direction of motion and the orientation of the line, after Hubel and Wiesel, 1968.

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fMRI



Activation in the right fusiform gyrus.
[Tarr, Cheng 2003]

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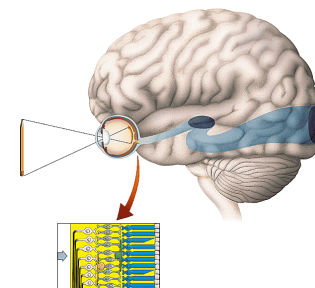
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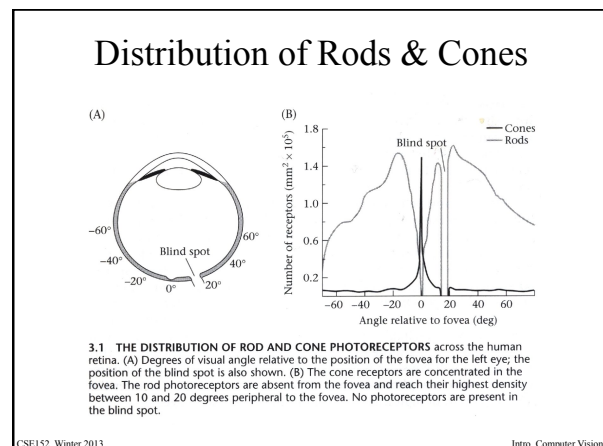
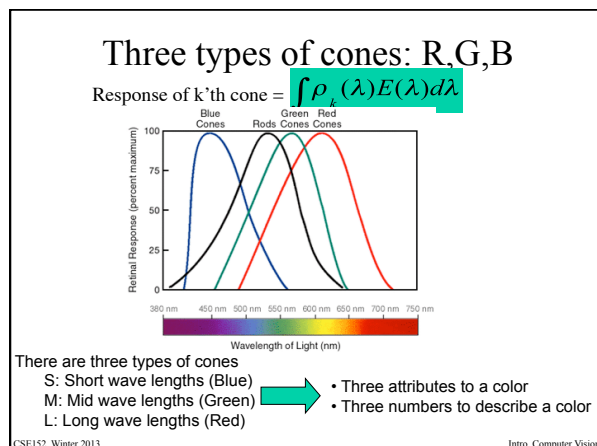
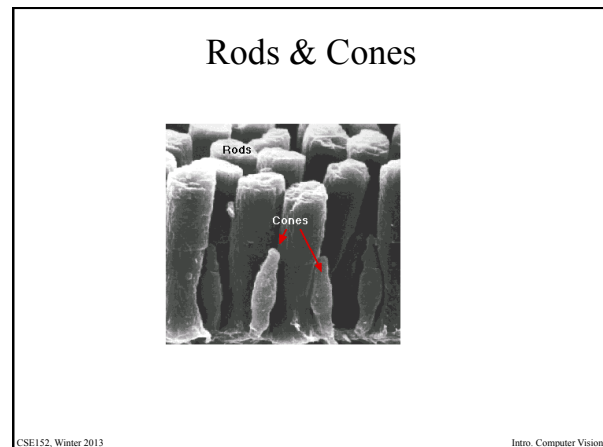
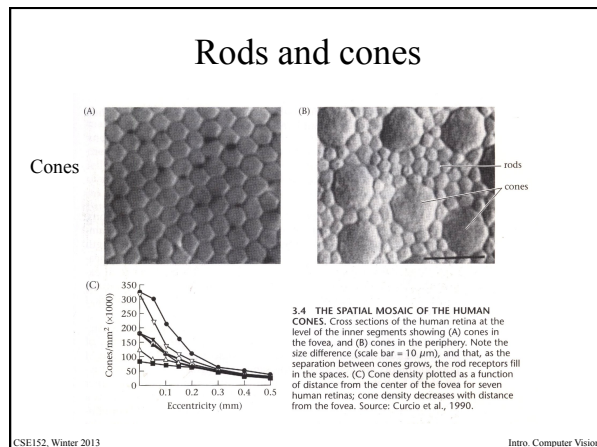
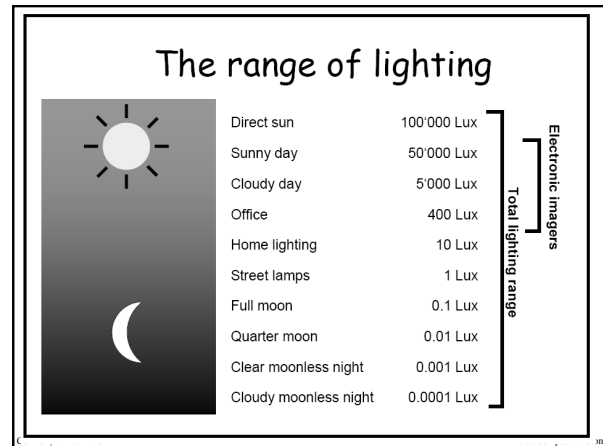
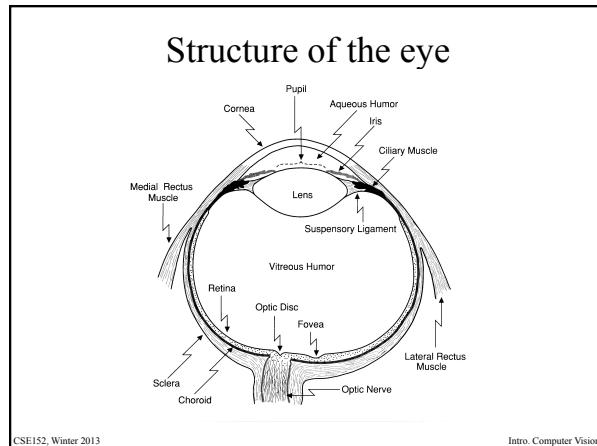
Computational Modeling



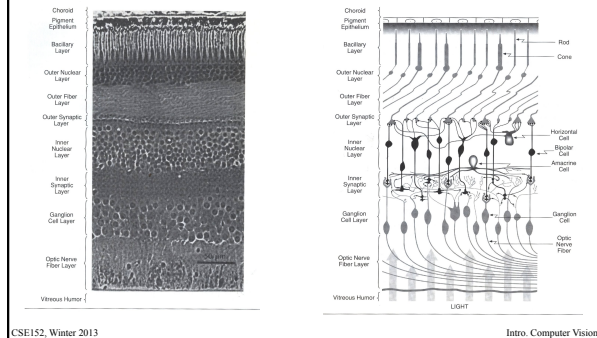
What is being computed and why?

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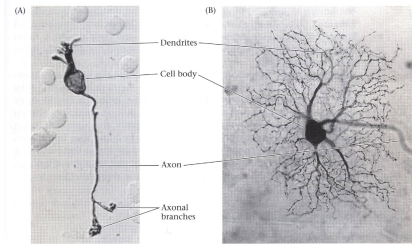
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Retina edge on



Retinal Neuron



5.2. RETINAL NEURONS have many different shapes and sizes. (A) The cell body of a bipolar cell resides in the inner plexiform layer. Its dendrites make contact with the photoreceptors and horizontal cells and its axon carries the output of the bipolar cell to the inner plexiform layer (see Figure 5.1), where it contacts the dendritic field of a ganglion cell. (B) The retinal ganglion cell bodies reside in the ganglion cell layer of the retina (see Figure 5.1). The axons of the retinal ganglion cells comprise the optic nerve. Several types of retinal ganglion cells can be distinguished based on the properties of their dendritic fields, their interconnections, and their cell bodies. The cell shown here was called a parasol cell by Stephen Polyak (1941, 1957). Sources: A from Yamashita and Wässle, 1991; B from Dacey and Peterson, 1992.

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Other Eyes

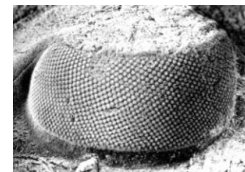
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Trilobite Visual System

- Most ancient known visual system.
- Compound eye with single crystal for each lens.

Electron Micrograph of
Holochroal eye



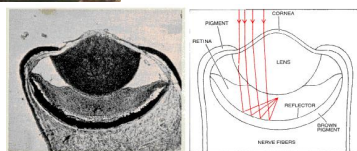
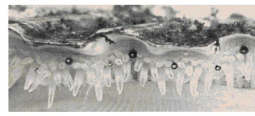
Good trilobite eye info at: <http://www.aloha.net/~smgon/eyes.htm>

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Scallop eyes

- Hundreds of primitives eyes, mirror in back
- Changes in light and motion and very rough images are registered on the retinas of the mollusk.
- Nice material at: <http://soma.npa.uiuc.edu/courses/bio303/Ch11b.html>



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Stomatopod eyes

- Dumb bell shaped, compound eyes
- Stereo vision with just one eye;
- Each eye is up on a stalk, with a wide range of motion;
- Stomatopods have up to 16 visual pigments stomatopods can also see ultra-violet and infra-red light, and some can even see polarized light.
- See <http://www.ucmp.berkeley.edu/aquarius/>



Larva Mantis Shrimp

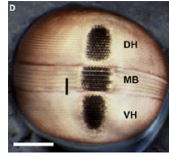


Adult Mantis Shrimp



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Mantis Shrimp

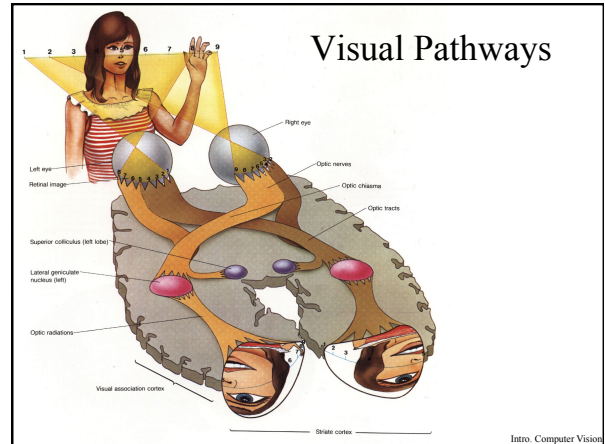


Trinocular vision

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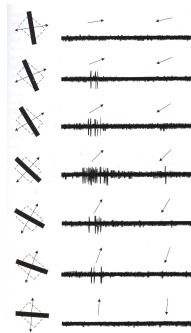
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Visual Pathways



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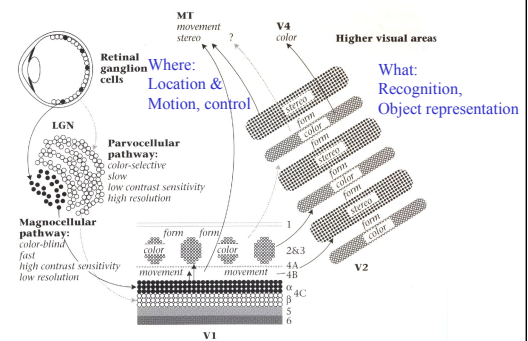
Single Cell Recordings



6.12 DIRECTION SELECTIVITY of a cortical neuron's response. The left-hand portion of each panel shows the receptive field location, the orientation of the line stimulus, and the two motion directions. The action potentials shown on the right are the neuron's response to motion in each of the two opposite directions. The neuron's response depends upon the direction of motion and the orientation of the line. After Hubel and Wiesel, 1962.

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6.23 AN ANATOMICAL/PERCEPTUAL MODEL OF THE VISUAL CORTEX. In this speculative model, visual streams within the cortex are identified with specific perceptual features. The anatomical streams are identified using anatomical markers; the perceptual properties are associated with the streams by applying the neuron doctrine. Source: Livingstone and Hubel (1988).

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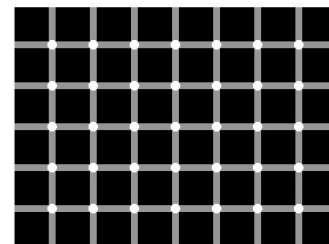
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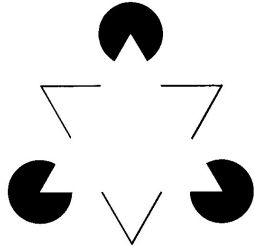
Fixate at center What color are the dots



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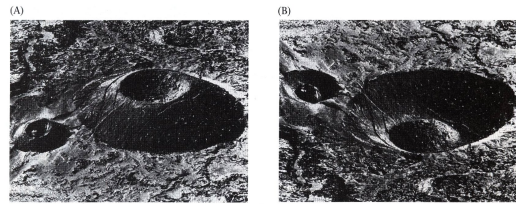
Subjective Contours Kanizsa's Triangle



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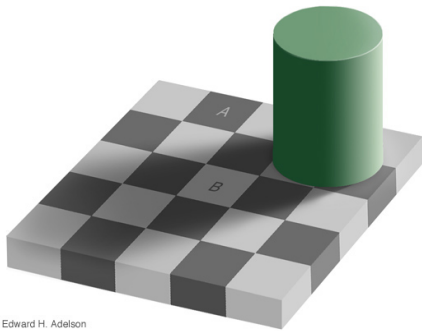
Shading Cues



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Which square is darker?



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Which square is darker?

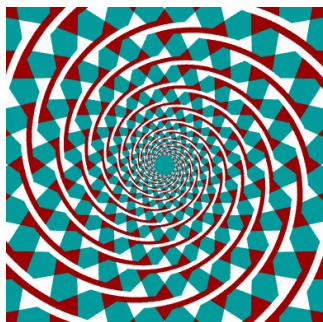


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Fraser's Spiral



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